

LAKE SHORE INC.
An Oldenburg Group Company
KINGSFORD, MICHIGAN

SHEET 1 OF 11
DATE 10/20/94
REVISED 01/31/95

TP-1073-AR-016
CDRL A010

MODULAR CAUSEWAY FERRY
VIBRATION MEASUREMENT
TEST PROCEDURE

TP-1073-AR-016

CUSTOMER ATCOM
CUSTOMER JOB NO. N/A
CUSTOMER P.O. NO. DAAK01-93-D0007
HULL NOS. First Article
EQUIPMENT Modular Causeway Ferry
EQUIPMENT NO. E03155
EQUIPMENT SERIAL NOS. P40P-0001, P40P-0002 (Powered Modules)
CUSTOMER NOTIFICATION PRIOR TO TESTING 7 DAYS
ENGINEERING NOTIFICATION PRIOR TO TESTING 14 DAYS
LAKE SHORE SALES ORDER NO. 1073AR

DRAWN W C Z DATE OCT 20, 1994
CHECKED R M Thompson DATE OCT 21, 1994
APPROVED W H H DATE OCT 21, 1994
QUALITY Kenneth J. Ulan DATE OCT 21, 1994

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DATE 10/20/94
REVISED January 31, 1995

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Rev	Date	Appvl	QA	Description
--	10/21/94	WJK	LSI 1 QA	Initial Issue
A	1/31/95	WJK	LSI 1 QA	Revised for direction of measurement at measurement locations; Added test for determining resonance.

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VIBRATION MEASUREMENT TEST PROCEDURE

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1.0 INTRODUCTION

1.1 Objective. The objective of the Vibration Measurement Test is to determine the vibration characteristics of the Propulsion System (including the main engine, reduction gears, thruster, drive shaft, and related equipment) of the Modular Causeway Ferry (MCF) while operating with rated load (350 short tons) at rated speed (6 knots). Testing shall demonstrate that vibration levels of the MCF do not cause severe or damaging vibrations within the Propulsion System or hull as defined by Mil-Std-167-2 for Types III, IV, and V mechanical vibrations.

1.2 Test Item. The test item, described as the MCF, is defined by Lake Shore drawing E03155. The MCF Powered Module is defined by Lake Shore Drawing E02843.

1.3 Test Limitations. Vibration Measurement Testing will be performed in conjunction with Speed Trial Tests, TP-1073-AR-012. Operating conditions are specified in the purchase description as rated load and rated speed. Vibration levels will be measured at intermediate speeds by sweeping through the operating speed range. Measurement locations will be determined by SNAME Codes C-1 and C-4 and through interpretation of Mil-Std-167-2. As specified by Mil-Std-167-2, no testing is required for Type V Lateral Vibration of propulsion shafting.

2.0 REFERENCE DOCUMENTS

- | | | |
|-----|----------------|--|
| 2.1 | PD 1990-0098 | Purchase Description (Para's 4.5.2.7.7, 3.5.8) |
| 2.2 | Mil-Std-167-2 | Mechanical Vibrations of Shipboard Equipment (Reciprocating Machinery and Propulsion System & Shafting) Types III, IV, & V |
| 2.3 | E20001 | General Test Requirements |
| 2.4 | E20011 | Failure Reporting, Analysis, and Corrective Action System (FRACAS) |
| 2.5 | SNAME Code C-1 | Technical & Research Code, Code for Shipboard Vibration Measurement |

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2.6 SNAME Code C-4

Technical & Research Code, Code
for Local Shipboard Structures and
Machinery Vibration Measurements

3.0 TEST PREPARATION

3.1 Approach to Test. The vibration levels of the MCF power train will be determined by measuring and recording the vibration levels in terms of vibration frequency (in Hertz) and vibration amplitude (in inches) and comparing the vibration levels to the forcing function (i.e., the drive train rotational speed) creating the vibration.

Vibration levels will be measured at the hull stern (three axes), and at the machinery foundations of the diesel engine (vertical) and thruster (longitudinal). Vibration levels will be measured at the operator's cab (principle axis). If there is evidence of excessive vibration at any local structure, vibration levels will be measured at that location. Torsional vibration will be measured at the front end of the diesel engine crankshaft.

3.2 General Test Requirements. Refer to the following documents for general test requirements:

E20001

General Test Requirements; location and schedule of test, calibration requirements, safety requirements, and general test documentation.

E20011

Failure Reporting, Analysis, and Corrective Action System (FRACAS).

3.3 Customer Notification. The ATCOM and Government Quality Assurance Representative shall be provided with seven (7) days notification prior to the start of testing.

3.4 Personnel Requirements. The following personnel are required for performance of the Vibration Measurement Test:

3.4.1 Contractor furnished personnel: Test supervisor, MCF operators, MCF crew, test equipment technicians.

3.4.2 Government furnished personnel: Dock side personnel for mooring, fueling, and rigging and handling the MCF load.

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- 3.5 Facilities and Test Equipment. The following facilities, support equipment, and test equipment are required for performance of the Vibration Measurement Test (CFE = Contractor furnished equipment, GFE = Government/Customer furnished equipment):

CFE GFE

- | | | |
|-------|--|---|
| 3.5.1 | One (1) complete MCF, outfitted for duty: | X |
| 3.5.2 | A measured course of known distance: | X |
| 3.5.3 | Vibration measurement instrumentation including accelerometers, velocity transducers, integrators, amplifiers, tape recorder, oscillograph, and/or vibration analyzer. | X |
| 3.5.4 | 350 short tons of load with rigging for handling the load: | X |
| 3.5.5 | Diesel fuel oil, ASTM D975 Grade 2-D or equal: | X |
| 3.5.6 | Mooring lines and dockside equipment for mooring the MCF to the pier: | X |

- 3.6 The instrumentation for measuring vibration levels shall be installed to the MCF Powered Module and Operator's Cab at locations indicated in ¶ 4.4.

4.0 TEST PROCEDURE

4.1 Vibration Measurement Testing will be performed in conjunction with the Speed Trial Tests, TP-1073-AR-012. Vibration levels will be measured as the MCF traverses the measured course at full load and full speed. Test documentation shall be recorded on the Test Report TR-1073-AR-016. Unless otherwise defined, testing and test documentation shall be in accordance with SNAME Codes C-1 and C-4.

4.2 Identify all instrumentation used to measure vibration levels (including make, model, serial number) and the calibration procedures and data for the instrumentation.

4.3 Test conditions shall meet the following restrictions.

4.3.1 The test shall be conducted in not less than 20 feet of water.

4.3.2 The test shall be conducted in a quiet sea (Sea State 2 or less).

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4.3.3 The test shall determine any resonances of the system by operating the diesel engine through a sweep of the full operating speed range of the engine. If any resonances are found, vibration data shall be taken at the offending engine speed.

4.3.4 The test shall be conducted with the MCF loaded with 350 short tons of cargo and operating at 6 knots.

4.3.5 The test shall be conducted with the MCF being steered in a straight ahead direction with minimum steering action during testing. As test conditions allow, testing may also include vibrations measurements under hard turn conditions.

4.4 Measure and record the vibration data (amplitude of vibration, frequency of vibration, diesel engine speed) for each location identified.

4.4.1 Hull stern location: longitudinal, vertical, athwartship.

4.4.2 Diesel engine foundation: vertical.

4.4.3 Thruster foundation: longitudinal.

4.4.4 Operator's Cab location: Principle axis of vibration.

4.4.5 Local Structure location (identified as having excessive vibration): longitudinal, vertical, athwartship. Identify location of local structure and direction of vibration.

4.4.6 Diesel engine crankshaft: torsional, event marker.

5.0 Acceptance Criteria

5.1 Testing shall demonstrate that vibration levels of the MCF do not cause severe or damaging vibrations within the Propulsion System or hull as defined by Mil-Std-167-2 for Types III, IV, and V mechanical vibrations.

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VIBRATION MEASUREMENT TEST

TEST REPORT

TR-1073-AR-016

CUSTOMER ATCOM

CUSTOMER P.O. NO. DAAK01-93-D-0007

EQUIPMENT MODULAR CAUSEWAY FERRY

POWERED MODULE SERIAL NO. P40P-001 & 002

SHOP ORDER _____

TEST COMPLETION DATE JUNE 5, 1996

Instrumentation and Calibration Data _____

Vibration Measurement Data

50% REPORT BY NKF FOR VIBRATION DATA

Test Data Sheets Attached — Acceptable — Not Acceptable —

Accept no excessive or damaging vibration.

Test Witnessed by:

LSI Rep *[Signature]* Customer Rep *[Signature]* Other *[Signature]*



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Vibration Measurements:

DATA IN NKE REPORT

MODULAR CAUSEWAY FERRY VIBRATION TEST DATA RECORDING SHEET					SEA STATE				DRAFT				
					DEPTH				DISPL				
TEST CONDUCTOR: _____ DATE: _____			RUN: _____		RUN: _____		RUN: _____		RUN: _____		RUN: _____		
			BEG: _____		BEG: _____		BEG: _____		BEG: _____		BEG: _____		
			END: _____		END: _____		END: _____		END: _____		END: _____		
		OPERATING CONDITION											
		TAPE CHAN	AMP CHAN	TAPE FS	AMP GAIN	TAPE FS	AMP GAIN	TAPE FS	AMP GAIN	TAPE FS	AMP GAIN	TAPE FS	A G
Waterjet F/A		1	1										
Engine Vert		2	2										
Hull F/A		3	3										
Hull Athw		4	4										
Hull Vert		5	5										
Ctrl Cab *		6	6										
Torsiograph		7	N/A										
Rev Marker		8	N/A										
TEST WITNESSED BY:										SHEET NO.			
LSI REP.						CUSTOMER REP.							
COMMENTS:													

* Principle direction

Use additional sheets as necessary

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Vibration Measurements:

MODULAR CAUSEWAY FERRY VIBRATION TEST DATA RECORDING SHEET					SEA STATE				DRAFT				
					DEPTH				DISPL				
TEST CONDUCTOR: _____ DATE: _____			RUN: _____ BEG: _____ END: _____		RUN: _____ BEG: _____ END: _____		RUN: _____ BEG: _____ END: _____		RUN: _____ BEG: _____ END: _____		RUN: _____ BEG: _____ END: _____		
		OPERATING CONDITION											
	TAPE CHAN	AMP CHAN	TAPE FS	AMP GAIN	TAPE FS	AMP GAIN	TAPE FS	AMP GAIN	TAPE FS	AMP GAIN	TAPE FS	AMP GAIN	A G.
Waterjet F/A	1	1											
Engine Vert	2	2											
Hull F/A	3	3											
Hull Athw	4	4											
Hull Vert	5	5											
Ctrl Cab *	6	6											
Torsiograph	7	N/A											
Rev Marker	8	N/A											
TEST WITNESSED BY:										SHEET NO.			
LSI REP.					CUSTOMER REP.								
COMMENTS:													

* Principle direction

Use additional sheets as necessary

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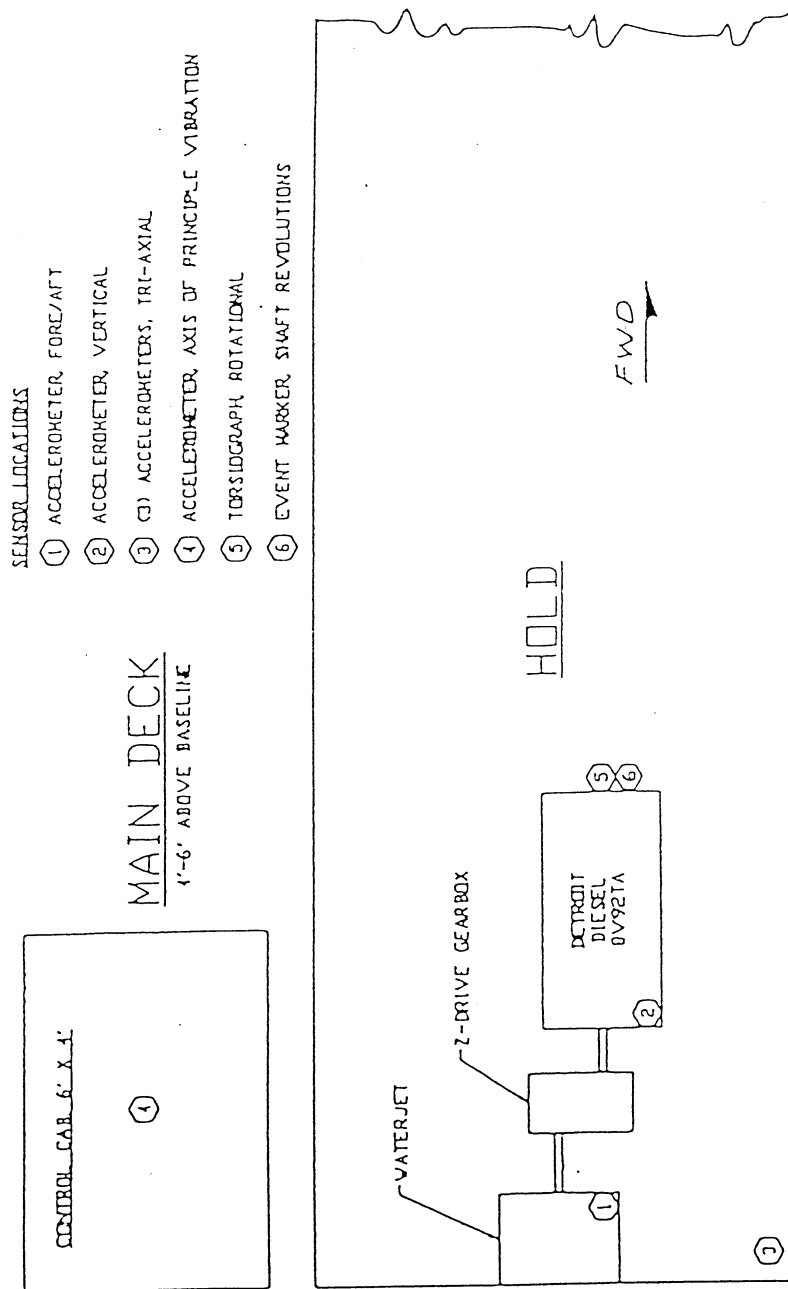


Figure 1. Vibration Sensor Locations

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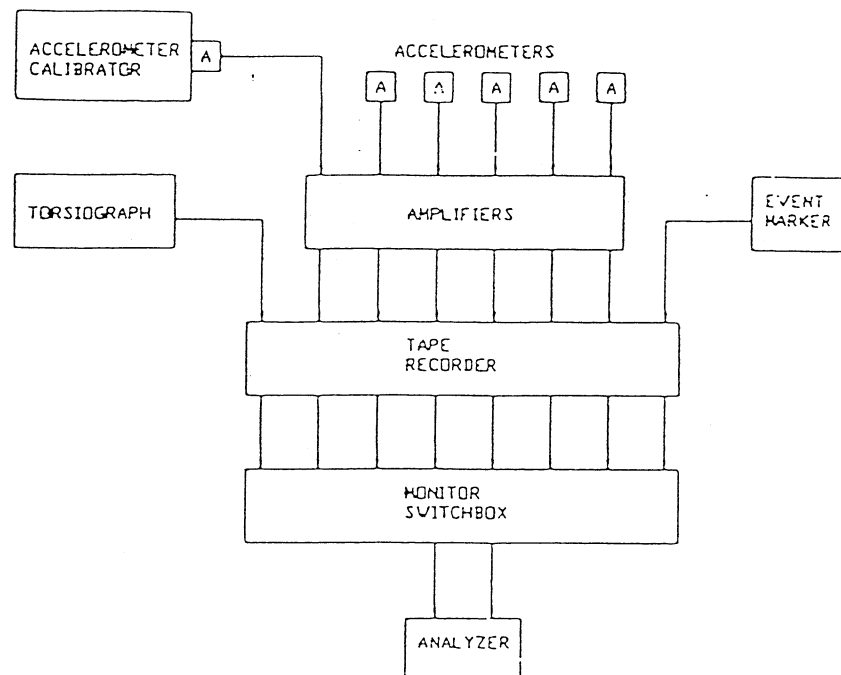


Figure 2. Instrumentation Block Diagram for Accelerometer Calibration Mode

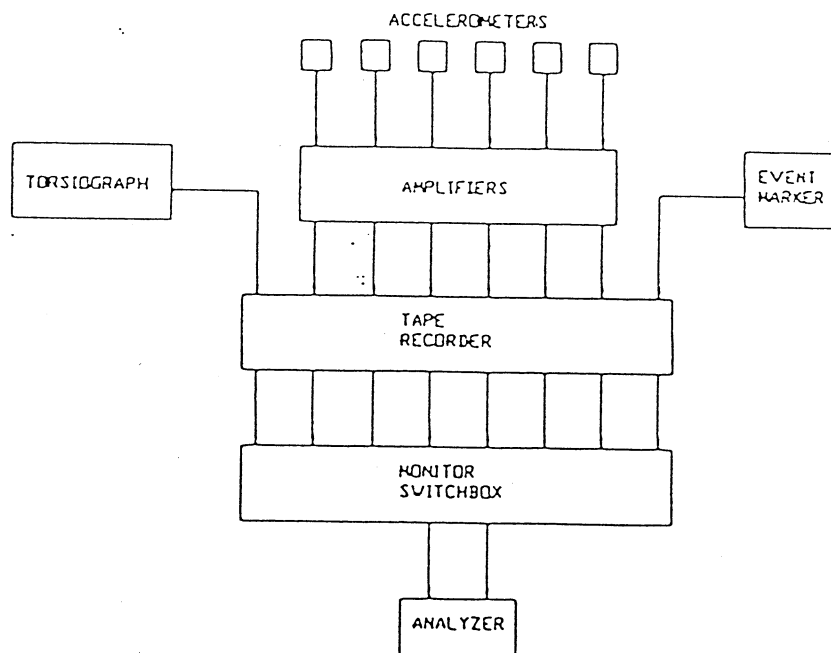


Figure 3. Instrumentation Block Diagram for Data Recording Mode

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